# Rural electrification revisited : the case of Bihar, India

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# Rural Electrification Revisited: The Case of Bihar, India

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**Abstract**

This study describes the dynamic processes of electrification. Some electrified villages have experienced de-electrification, mainly due to technical issues. Some villages were re-electrified through various efforts. Our econometric exercise indicates that small villages in remote locations tend to not be prioritized in the electrification process. It also finds that the cumulative number of ever-electrified villages is higher among villages having a higher ratio of socially advanced classes. However, some of these experienced de-electrification, rendering ambiguous the impact of village social characteristics on electrification.

**Keywords:** Electrification, de-electrification, re-electrification, Bihar, India
**JEL classification:** P25, Q01, Q40, R11

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## 1. Introduction

Rural electrification has been an important development agenda in India since independence as it can bring considerable economic and social benefits to rural households and society.[1] When India gained independence in 1947, only 1,500 villages were electrified (Government of India, 2011), but this number jumped to more than 560,000 villages as of the end of March 2012.[2] Roughly 94% of all villages in India have access to electricity by the current definition of rural electrification.[3] Six of the major states (Andhra Pradesh, Haryana, Karnataka, Kerala, Punjab, and Tamil Nadu) have attained 100% village-level electrification. The rate is high even in low-income states. For example, it is almost 90% in Bihar (89.9%).[4]

This was achieved by a series of initiatives by the Union government, particularly thanks to the flagship rural electrification program *Rajiv Gandhi Grameen Vidyutikaran Yojana* (RGGVY: Rajiv Gandhi Rural Electrification Programme), which started in April 2005.[5] It aims to electrify villages, particularly focusing on rural Below

[1] See Barnes (1988) for a detailed survey on the socioeconomic benefits of electrification.

[2] Data are from indiastat (http://www.indiastat.com). The original data are from the Ministry of Power, Government of India.

[3] Prior to October, 1997, the definition was as follows: "A village should be classified as electrified if electricity is being used within its revenue area for any purpose whatsoever." For example, a village would be deemed as electrified if any of its irrigation pumps use electricity. However, the definition was changed in 1997 as follows: "A village will be deemed to be electrified if the electricity is used in the inhabited locality, within the revenue boundary of the village for any purpose whatsoever." The definition was further modified in February 2004 to the one that remains in use. According to the website of the Ministry of Power, Government of India (http://www.powermin.nic.in); "As per the new definition, a village would be declared as electrified, if : 1) basic infrastructure such as Distribution Transformer and Distribution lines are provided in the inhabited locality as well as the *Dalit Basti* hamlet where it exists, 2) electricity is provided to public places like Schools, *Panchayat* Office, Health Centers, Dispensaries, Community centers etc., and 3) the number of households electrified should be at least 10% of the total number of households in the village."

[4] According to the latest statistics, the percentage of villages electrified in Bihar as of May 31, 2015 is 95.5% (https://data.gov.in/catalog/progress-report-village-electrification, accessed on Oct. 18, 2015).

[5] RGGVY merged several electrification programs, such as *Kutir Jyoti Yojana* (launched in 1988–89), and the Accelerated Electrification of One-*Lakh* (100,000) Villages and One-*Crore* (10 million) Households (launched in 2004–05). The program aims to electrify one *lakh* villages and provide access to electricity for 2.34 *crore* rural BPL households. Under this scheme, there is provision for a 90% capital subsidy by the Union government for rural electrification infrastructure, with the remaining 10% soft-loaned by the Rural Electricity Corporation to State governments. The program also funds un-electrified BPL households with a 100% capital subsidy for electrification.

Poverty Line (BPL) households. As of December 31, 2011, a total of 100,917 un-electrified villages had been electrified and 179.41 *lakh* (17.941 million) BPL households gained free electricity connections under the RGGVY programme.[6] Since the targets set by *Bharat Nirman*, which is a governmental time-bound action plan for rural infrastructure that aims for the RGGVY programme to electrify an additional one *lakh* (100,000) villages and to provide free electricity connections to 175 *lakh* BPL households by March 2012; these figures are enough to achieve the targets well before the deadline.[7] Judging from the information so far, rural electrification is making progress under the RGGVY programme.

However, through our two rounds of village surveys in 2008-09 and 2011-12 in Bihar, we noticed that the status of rural electrification is not static but rather more dynamic. We observed that several electrified villages underwent de-electrification. Some of them became re-electrified but others were not. One problem seems to be that many of these de-electrified villages are likely still counted as electrified villages in the official figures. Oda (2012) pointed this out from a survey in East Champaran district in Bihar. He suspects that the Ministry of Power (MOP) counts villages as being electrified if a transformer has ever been installed. The actual situation at the local level contradicts official information released by the government, and this may cast doubt on the credibility of the MOP's figures.

In essence, this study is an update and re-examination of Oda and Tsujita (2011). We address the issue of de-electrification and also re-investigate the determinants of rural electrification at the village level using data from a survey conducted in rural Bihar. This study's contribution is to investigate complicated processes of electrification, de-electrification and re-electrification, which are largely overlooked by the existing literature. In our previous study, we analyzed the determinants of rural electrification using information from one particular time, which did not take into account the process of village de-electrification and re-electrification (Oda and Tsujita, 2011). An un-electrified village at the time of a particular survey does not necessarily mean that the village has never been electrified; it could happen that the village was electrified but later de-electrified. Since the characteristics of an un-electrified village that has never been electrified and an un-electrified village that used to be electrified differ, grouping them together as un-electrified villages should be

[6] Figures are from the website of the Ministry of Power, Government of India (http://www.powermin.nic.in/), accessed on March 14, 2012. There are some discrepancies in the data.

[7] Under *Bharat Nirman*, action plans for rural infrastructure in the areas of irrigation, roads, rural housing, rural water supply, rural electrification, and rural telecommunication connectivity are proposed. Visit *Bharat Nirman*'s website (http://www.bharatnirman.gov.in) for more details.

avoided. Therefore, the determinants of rural electrification require re-investigation.

This study is organized as follows: Section 2 describes the selection of surveyed villages; Section 3 discusses the progress and ground reality of electrification including de-electrification and re-electrification of villages; Section 4 re-examines determinants of rural electrification at the village level using econometric analyses to describe the influencing factors; and Section 5 concludes.

## 2. Selection of Surveyed Villages

To investigate the status of rural electrification, we carried out a village-level survey in 80 villages during 2008–09 and revisited the same village in 2011–12. Both rounds of the survey were conducted in Bihar, one of India's underdeveloped states. Given Bihar's three-tiered organization for rural self-government at district, block, and village (*gram*) levels, known as the *panchayat* system, we used the following method to select the surveyed 80 villages.

First, five districts in Bihar state (Bhagalpur, East Champaran, Kishanganj, Madhubani, and Rohtas) were selected, one from each of the five district groupings, in accordance with ranking on the livelihood potential index (for details, see Ghosh, 2007). This index is compiled on the basis of availability of land per rural household, cropping intensity, agricultural productivity, head of cattle per 1000 people, and percentage of urban population. Since approximately 90% of the state's population resides in rural areas and nearly 80% of its rural workforce is engaged in the agriculture sector, indicators related to farming and farming-related activities were regarded as the most important criteria for measuring livelihoods. Each district's socioeconomic characteristics are provided in Table 1.

Table 1 Socioeconomic indicators for surveyed districts

| District | Survey year | Rohtas | Kishanganj | Bhagalpur | Madhubani | East Champaran | Bihar | India |
|---|---|---|---|---|---|---|---|---|
| Population (millions) | 2011 | 2.96 | 1.69 | 3.03 | 4.48 | 5.08 | 104.1 | 1210.57 |
| Per capita net district domestic product in 2004-05 prices (INR) | 2011-12 | 13909 | 9928 | 17324 | 9241 | 10735 | 14574 | 38048 |
| Literacy rate (%) | 2011 | 75.59 | 57.04 | 64.96 | 60.90 | 58.26 | 63.82 | 73.0 |
| Infant mortality rate (per 1,000 births) | 2011-12 | 49 | 58 | 51 | 52 | 53 | 52 | 57.0 |
| Proportion of SCs (%) | 2011 | 18.55 | 6.69 | 10.51 | 13.12 | 12.78 | 15.96 | 16.6 |
| Proportion of Muslims (%) | 2011 | 10.2 | 68.0 | 17.7 | 18.2 | 19.4 | 16.9 | 14.2 |
| Availability of land per rural household (hectare) | 2003-04 | 0.84 | 0.57 | 0.42 | 0.35 | 0.47 | 0.45 | - |
| Cropping intensity | 2011/12 | 1.35 | 1.42 | 1.32 | 1.32 | 1.54 | 1.42 | - |
| Agricultural productivity (yield of paddy, kilogram of rice per hectare) | 2012/13 | 2,013 | 1,381 | 1,915 | 1,093 | 1,875 | 2,523 | - |
| Head of cattle per 1,000 people | 2005 | 235 | 241 | 197 | 198 | 132 | 196 | - |
| Percentage of urban population | 2011 | 14.43 | 9.68 | 19.79 | 3.68 | 7.85 | 11.3 | 31.2 |

*Note:* For India, pet capita net district domestic product is per capita net national income in 2004/05 prices.

Source: Census of India website (http://censusindia.gov.in/); Central statistics office website

(http://mospi.nic.in/Mospi_New/Site/home.aspx); Ghosh (2007); Mishra (2012); Government of Bihar (2015); Singh and Tiwari (undated).

Second, we randomly selected four blocks from each district and four *gram panchayats* (GPs) from each selected block. We then conducted field visits to each GP, during which we selected one village on the basis of two criteria: (1) caste composition, and (2) population size that best represented a given GP.

Village-level surveys were carried out in all selected villages, the components of which included questions on socioeconomic characteristics; physical infrastructure, including electricity, water, and sanitation; road conditions; housing; access to social services, including education, healthcare, and the public distribution system; land and agriculture; labor and migration; implementation of government schemes; *panchayat* election history; and social aspects of the community.

## 3. Village-Level Electrification, De-electrification, and Re-electrification

Out of the 80 surveyed villages, 66 villages (82.5%) have been electrified according to the definition of electrification that holds that a village is electrified in 2011–12 if any one household in the village is connected to electricity. As Table 2 shows, rural electrification started as early as the 1950s. However, the electrification process accelerated after 2005 when RGGVY was introduced. Indeed, under the RGGVY, 26 villages were electrified for the first time.

Table 2 Chronology of first electrification among ever-electrified villages (number of villages)

| | Rohtas | Kishanganj | Bhagalpur | Madhubani | East Champaran | Total |
|---|---|---|---|---|---|---|
| 1950s | 0 | 0 | 0 | 0 | 1 | 1 |
| 1960s | 1 | 0 | 2 | 0 | 2 | 5 |
| 1970s | 4 | 1 | 0 | 4 | 2 | 11 |
| 1980s | 1 | 1 | 2 | 5 | 1 | 10 |
| 1990s | 0 | 2 | 2 | 0 | 3 | 7 |
| 2000-2004 | 1 | 1 | 3 | 1 | 0 | 6 |
| After 2005 | 6 | 9 | 5 | 3 | 3 | 26 |
| Total | 13 | 14 | 14 | 13 | 12 | 66 |
| No. of surveyed villages | 16 | 16 | 16 | 16 | 16 | 80 |
| Electrified villages (%) | 81.3 | 87.5 | 87.5 | 81.3 | 75.0 | 82.5 |

Source: Our field surveys

How were the sample villages electrified for the first time? Regardless of the initial motivations, such as demand for electricity for irrigation purposes, learning of electrification from neighboring villages, and so on, the overwhelming majority of villages worked hard for years to obtain electricity (Table 3). Collective action initiated by village leaders, such as elected village chief (*Mukhiya*), government school teacher, freedom fighter, social worker, local singer, government employee, and so on, led to village electrification. Some villages actively lobbied politicians such as local Members of Parliament and/or Members of Legislative Assembly. For example, villagers in one sample village had collectively struggled for nearly 10 years to get the village electrified by mainly approaching the local electricity department. However, when they directly approached a powerful politician, the village was immediately electrified simply due to his authority. In four sample villages, politicians themselves played a leading role in electrification within their constituency. For example, one village was electrified just before a national assembly election when the candidate visited the village. In contrast, 18.2% of villages were electrified without needing to make any particular effort, but were rather electrified under RGGVY. The village's collective bargaining power in rural electrification has shrunk in recent years (Oda and Tsujita, 2011). Nevertheless, it is indicated that villagers' collective action played an important role in initial rural electrification until recently and as we discuss later, remains influential in terms of re-electrification.

Table 3 Processes of first-ever electrification among ever-electrified villages (number of villages)

| | No. of villages | (%) |
|---|---|---|
| Villagers' initiation or collective action | 32 | 48.5 |
| Villager's collective action and approaching politicians | 15 | 22.7 |
| No particular effort | 12 | 18.2 |
| Politicians' initiatives | 4 | 6.1 |
| Villager's collective action and approaching contractors | 1 | 1.5 |
| Government facility nearby | 1 | 1.5 |
| Unknown | 1 | 1.5 |
| Total | 66 | 100.0 |

Source: Our field surveys

While the official statistics indicate steady progress in rural electrification, the reality on

the ground differs from the picture painted in the report published by the Ministry of Power (MOP). Table 4 shows the number of electrified villages at the time of the 2008–09 and 2011–12 surveys. Overall, the number of currently electrified villages increased from 43 to 55 within roughly three years. However, a closer look at the data reveals that electrification progress varies by district. For example, Kishanganji, the most backward among the sample districts, actually benefitted from the RGGVY program, with the number of electrified villages increasing from 4 to 12 (out of 16) villages, while it declined from 13 to 11 villages due to de-electrification in Rohtas district, the most affluent among the surveyed districts and where electrification for agricultural purposes had started as early as the 1960s. This evidence shows the success of RGGVY in bringing electricity to villages in underdeveloped districts, which is the main objective of the programme, but it also confirms the issue of de-electrification as one needing to be discussed.

It is likely that many of these de-electrified villages continue to be counted as electrified villages in the official figures as pointed out by Oda (2012). He notes that the actual situation at the local level contradicts official information released by the government, and this may cast doubt on the credibility of the MOP's figures.

Table 4 Number of electrified villages at the time of the surveys

| | | Rohtas | Kishanganj | Bhagalpur | Madhubani | East Champaran | Total |
|---|---|---|---|---|---|---|---|
| No of surveyed villages | | 16 | 16 | 16 | 16 | 16 | 80 |
| No. of ever-electrified villages in 2008/09 | No. | 13 | 4 | 12 | 12 | 10 | 51 |
| | % | 81.3 | 25.0 | 75.0 | 75.0 | 62.5 | 63.8 |
| No. of currently electrified villages in 2008/09 | No. | 13 | 4 | 10 | 9 | 7 | 43 |
| | % | 81.3 | 25.0 | 62.5 | 56.3 | 43.8 | 53.8 |
| No. of ever-electrified villages in 2011/12 | No. | 13 | 14 | 14 | 13 | 12 | 66 |
| | % | 81.3 | 87.5 | 87.5 | 81.3 | 75.0 | 82.5 |
| No. of currently electrified villages in 2011/12 | No. | 11 | 12 | 12 | 12 | 8 | 55 |
| | % | 68.8 | 75.0 | 75.0 | 75.0 | 50.0 | 68.8 |

Source: Our field surveys

Although the number of electrified villages increased, electricity supply remains unstable. For example, electricity comes only 10.7 days a month on average in bad months, while 29% of the electrified villages (16 villages) receive less than a week's supply in bad months. During the field surveys, we often came across electrified villages that did not receive any electricity supply for several months or even longer.

At the same time, when electricity is available, availability of electricity in electrified villages increased both in good months and bad months (Table 5). There is no

clear tendency regarding which months villages are more likely to get electricity; however, interestingly two villages reported that electricity supply was far better when the chief minister visited the area. In contrast, bad months tend to be summer (May, June and July) when the demand of electricity is high to avoid heat (more than 40°C).

Table 5 Availability of electricity in electrified villages

| | | Available days per month | Available hours per day | |
|---|---|---|---|---|
| | | 2011/12 | 2008/09 | 2011/12 |
| No. of currently electrified | | 55 | 43 | 55 |
| In good months | Average | 21.1 | 6.6 | 9.0 |
| | Std. Dev. | 7.0 | 6.0 | 4.4 |
| | Max | 30 | 24 | 20 |
| | Min | 5 | 1 | 2 |
| In bad months | Average | 10.7 | 1.8 | 2.8 |
| | Std. Dev. | 6.4 | 2.9 | 2.0 |
| | Max | 30 | 10 | 10 |
| | Min | 0 | 0 | 0 |

Note: Data on available days per month in 2008/09 is unavailable
Source: Our field surveys

The proportion of electrified households in the electrified villages also increased in 2011-12 (Table 6). However, the number of "completely electrified" villages wherein all households receive electricity totals only one village in 2008-09 and three villages in 2011-12.[8] Moreover, the latest government's definition of electrified village includes at least 10% of total households in a village being electrified. According to this criterion, two villages in 2008-09 and one village in 2011-12 are not officially defined as electrified.

Our field survey found that households were slowly electrified within a village. Initially, electrified households were limited to a single household, only the *Mukhiya*'s house in extreme cases, to a few households in the old days, and more households in recent years under RGVVY. Other households were legally or illegally connected to electricity based on households' economic conditions, geographical proximity of wires, and so on (for further details, see Oda, 2014).

As a result of unstable and limited electricity supply in terms of amount of time and households covered, 52 out of 55 electrified villages still depend upon kerosene as a

[8] See Oda and Tsujita (2015) for an analysis of which households have access to electricity by using a household data set from the same Bihar villages.

primary source of lighting in 2011–12. During our surveys, we often came across privately installed wires from a local diesel-powered electrical generator. Typically, villagers buy small quantities of electricity from a *generator wallah* (a person who owns an electrical generator) to power a light bulb for three hours in the evening.[9] This kind of business is mushrooming. Half of the surveyed villages have at least one *generator wallah*. Villagers are willing to pay in cash or in kind (kerosene or diesel) for electricity provided by generators. Even though many villages are receiving electricity, the supply is limited in terms of quantity and quality. Furthermore, wide variations exist between villages in terms of the quantity of electricity received. Eight hours' supply a day is the norm to be deemed as electrified, but many villages only receive a few hours' supply a day in bad months. This situation has brought about this type of new business.

Table 6 Proportion of electrified households in electrified villages

| | 2008/09 | | 2011/12 | |
|---|---|---|---|---|
| | No. | % | No. | % |
| Less than 10% | 2 | 4.65 | 1 | 1.85 |
| 10-49% | 30 | 69.77 | 22 | 40.74 |
| 50-99% | 10 | 23.26 | 27 | 50.00 |
| 100% | 1 | 2.33 | 3 | 5.56 |
| Unknown | 0 | 0.00 | 2 | 3.70 |
| No. of currently electrified villages | 43 | 100.00 | 55 | 101.85 |
| Average (%) | 31.4 | | 53.0 | |

Source: Our field surveys

Importantly, 36 villages had experienced de-electrification, defined as having lost their electricity connection after initial electrification at least once in the past. The main reason for de-electrification was failure of the installed transformer (Table 7). Transformers in 26 de-electrified villages burned out due to excessive load. The load capacity of transformers provided by the government is 16 kVA, which is not sufficient to support the existing—let alone rising—demand for electricity. The other major reason is theft of wire, transformers, and transformer coils. These items are commonly stolen in rural areas to collect metal to sell for cash.

Some villages, particularly those electrified a long time ago, undergo repeat cycles of electrification and de-electrification (and re-electrification). For example, one village was first electrified in 1969. The transformer has been burnt out five or six times

[9] At a village in Madhubani, the fee was INR 75 per bulb per month (the figure from our field survey in 2011).

since then. Every time, villagers approached the electricity department and the transformer was repaired, but only after some time. On average, villages face de-electrification 7.3 years after initial electrification. However, this figure includes three villages that lasted more than 40 years without de-electrification. Excluding those villages, the interval between electrification and de-electrification is only 3.9 years on average, and 14 villages were de-electrified within two years of their first-ever-electrification. One village was de-electrified within two weeks due to transformer burnout. De-electrification is mainly due to technical reasons. If the government continues to supply transformers of this same capacity, villages, including some recently electrified villages, are doomed to a future of de-electrification.

Table 7 Reasons for de-electrification (multiple answers)

| Reason | No. of villages | % |
|---|---|---|
| Transformer burned out | 26 | 70.3 |
| Theft of wire | 11 | 29.7 |
| Theft of transformer | 2 | 5.4 |
| No electricity supply | 2 | 5.4 |
| Wire fell down | 1 | 2.7 |
| Theft of transformer coil | 1 | 2.7 |
| Flood | 1 | 2.7 |
| Collapse of whole electricity infrastracture | 1 | 2.7 |
| Unknown | 1 | 2.7 |
| Total no. of de-electrified villages | 36 | 97.3 |

Source: Our field surveys

The survey suggests that once the village becomes de-electrified, it is not easy to electrify again. Out of 36 de-electrified villages, only 23 villages were re-electrified. Some villages were re-electrified through the “normal” process of the RGGVY without exerting a particular effort, but a majority were not. As Table 8 indicates, villagers’ efforts were necessary to get the village re-electrified in the majority of cases. Simply waiting for the government scheme is time-consuming, and there is no guarantee of success if additional efforts are not made. For example, some villages that experienced de-electrification in the early 1980s remained un-electrified at the time of the survey. Three villages experienced a lack of electricity for more than 20 years. On average, it takes 6.2 years for villages to become re-electrified after de-electrification. This figure has improved slightly in recent years due to the RGGVY. Under this scheme, nine

villages were re-electrified within one year.

In seven of the sample villages, re-electrification occurred not by asking the government for assistance but by collecting money to repair or purchase a new transformer. One village collected as much as INR 112,000 (approximately US$1,745, more than three times the per capita net state domestic product in Bihar in 2014-15) to buy a higher-capacity transformer.[10] This method of re-electrification is not simple. It requires leadership, and the village needs to be in agreement to contribute financially to the village. At least it is reasonable to suppose that most villagers have mutual interests, such as improving agricultural productivity by electrifying irrigation pumps and other agricultural equipment.[11]

Political power also plays an important role in re-electrification. The effects of political influence on the electrification process seem to have shrunk since the introduction of the RGGVY, but abundant anecdotal evidence indicates that it is still important, as we found in our surveys. Respondents from four villages said that they approached local members of the Legislative Assembly, Members of Parliament, or other political figures for the purpose of soliciting them to re-electrify the village (Table 8).

Table 8 Reasons for re-electrification (multiple answers)

| Reasons | No. of villages | % |
|---|---|---|
| Money collected by villagers to repair a transformer or purchase a new transformer | 8 | 36.4 |
| Government scheme, such as RGVVY or a rehabilitation program | 7 | 31.8 |
| Help of local MLA, MP, or politician | 4 | 18.2 |
| Villagers' joint efforts | 3 | 13.6 |
| Village chief's efforts | 3 | 13.6 |
| Total no. of re-electrified villages | 23 | 104.5 |

Source: Our field surveys

## 4. Re-examination of Determinants of Rural Electrification

This cycle of de-electrification and re-electrification of villages makes it difficult to accurately describe the status of rural electrification. In our 80 sample villages, we found that 51 villages had been electrified at least once by 2008–09. The number of ever-electrified villages, which is defined as having been electrified at least once, increased to 66 villages in 2011–12 while the number of never-electrified villages

[10] Interestingly, we found not only transformers but also electricity poles sold in the local market. Some villagers admitted that they bought new higher-capacity transformers and electricity poles by collecting contributions from villagers.

[11] Oda and Tsujita (2011) found (using their own Bihari village survey data) that villages with a functional agricultural cooperative, which is used as an instrumental variable for cohesion or unitedness of village, tend to be electrified.

decreased to 14. However, the numbers of electrified villages at the time of the survey was 43 in 2008-09 and 55 in 2011-12. It was also found that 36 villages that were once electrified became de-electrified. Electrified villages may become de-electrified at any time. This highlights the need, when examining such issues as the determinants of electrification, to distinguish between villages that have never been electrified and those that were once electrified but became de-electrified later. The former type of village differs fundamentally from the latter type, and the two types should not be grouped together as un-electrified villages.

***Methodology and Variables***

To estimate the determinants of electrification at the village-level using our survey data of 2008-09 and 2011-12, we employed a Probit estimation technique.[12] The dependent variable was a binary variable indicating whether or not a village was ever electrified. The value of the dependent variable takes 1 if a village was ever electrified and 0 if it has never been electrified. This means that a village that was de-electrified and recorded as un-electrified at the time of the survey is now included in the category of electrified villages. We used the old definition of electrification for simplicity: a village was considered electrified if at least one household had access to electricity. In addition, a binary variable of whether or not a village was electrified at the time of the visit was also used as the dependent variable in order to see how the difference in the definition of electrified villages affect estimated results.

The explanatory variables were the characteristics of the village, consisting of the number of households, social classes, remoteness of the village, and district dummies. The number of households was included to assess whether village size affects the electrification process. The social-class variable included the ratio of sum of Hindu general caste and Other Backward Classes (OBCs) households to the total households in the village. This is included to assess whether social (as well as economic) superiority affects the process of electrification. We consider that Hindu general castes and OBCs are superior to Extremely Backward Classes (EBCs), Scheduled Castes (SCs), and Muslims, and see if such a social class factor is important in terms of rural electrification.[13] The variable used for the remoteness of villages is the distance in

[12] We also examined the determinants of electrification using the 2008–09 survey data. The signs and significances of estimated parameters are identical.

[13] SCs are determined by the president or by each state government as socially/economically backward castes. They suffer discrimination and are known as "untouchable" in Hindu society. OBCs are broadly defined as socially and economically backward groups other than SCs. In Bihar, OBCs are divided into two groups: OBCs and EBCs. OBCs are regarded as being more empowered than EBCs. Muslim is also regarded as socioeconomically disadvantaged group.

kilometers from the nearest power sub-station to the village. A summary of the statistics of the variables is given in Table 9. Due to lack of data, we use the number of households and the ratio of sum of Hindu general and OBC households of 2008-09 for 2011-12 when analyzing the determinants of electrification of 2011-12, assuming that these numbers did not change much in between.

Table 9 Summary of descriptive statistics of explanatory variables

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| No. of households in 2011/12 | 80 | 448.38 | 511.32 | 99 | 3724 |
| Ratio of Hindu General and OBC in 2011/12 | 80 | 0.34 | 0.30 | 0 | 1 |
| Distance to sub-station | 80 | 11.1 | 8.58 | 0 | 41 |

***Estimation Results and Interpretation***

The results of the analysis are presented in Table 10. The estimated coefficients and their standard deviations based on 2008-09 survey data are shown in EQ(1), and the results using 2011–12 data are presented in EQ(2). In both cases, the dependent variable is defined by whether or not a village was ever electrified.

The size of the village in terms of household numbers has a significant positive explanatory power in both EQ(1) and EQ(2). As Andreas (2006) points out, there is a tendency for authorities to favor larger villages because of the large pool of potential electricity consumers and cost-effectiveness of connection.

The distance from the nearest power sub-station to the village, which represents the remoteness of the village, has a negative explanatory power, meaning that the location of the village does matter in both cases. This result is consistent with the findings of Andreas (2006, 2009) and Oda and Tsujita (2011). Villages in remote areas tend to be un-electrified due to cost ineffectiveness and technical difficulties.[14] We even came across an un-electrified remote village that was not on the map brought by government officials, according to the elected *gram panchayat* chief.

The estimates of variables representing social classes were significantly positive in EQ(1) and in EQ(2). This implies that a village with a higher ratio of socially and usually economically advanced classes was favored in getting electrified. One can interpret this tendency as a result of their exercising political power in the process of electrification. Though it is difficult to verify such a political influence empirically, during our survey, we noted that villages with the most political power, who usually came from socially advanced classes such as Hindu general caste groups, received an

[14] Chakrabarti and Chakrabarti (2002) report that the cost of electricity supply through a conventional grid connection increases considerably as the distance between grid and village increases.

electric supply on a priority basis. They often know who they should approach for the village to be electrified and how. Our result indicates that the social characteristics of the village do matter in electrification. Furthermore, such a tendency became more evident during the period of rapid expansion of electrification through the RGGVY as the value of the estimated coefficient on the social class variable increased significantly. In Bihar, the ratio of electrified villages to total number of villages as reported in the 2001 Census of India was 51.4%. This ratio increased to 94.2% by March 31, 2013 (Government of India, 2006, 2013).

The dependent variable employed in EQ(3) and EQ(4) is a binary variable indicating whether or not a village was electrified at the time of the visit. EQ(3) and EQ(4) are based on 2008-09 survey data and 2011-12 data, respectively. The estimated coefficients on the size of the village and the distance from the nearest power sub-station have the same signs and are also significant. However, the positive and significant impact of the social class variable observed in EQ(1) and EQ(2) disappeared. This is consistent with the finding by Oda and Tsujita (2011), who found that a village's social characteristics did not influence rural electrification because of the introduction of the RGGVY, the main objective of which is to provide electricity to poor rural areas. This difference might arise in part due to the difference in dependent variables. In EQ(1) and EQ(2), the dependent variable is defined by whether or not the village was ever-electrified, but is whether the village was electrified at the time of the survey in EQ(3) and EQ(4). Therefore, this result likely implies that as the RGGVY progresses, the number of electrified villages with a higher ratio of lower social classes increased in recent years, while villages with higher classes also increased, as evident in EQ(1) and EQ(2), but some of these underwent de-electrification and remain un-electrified, making the social characteristics of the village less important.

Table 10 Probit regression of determinants of rural electrification

| | Ever-electrified villages | | Currently electrified villages | |
|---|---|---|---|---|
| | EQ(1) | EQ(2) | EQ(3) | EQ(4) |
| No. of households | 0.0018 *** | 0.0060 *** | 0.0014 *** | 0.0025 *** |
| | *0.0006* | *0.0022* | *0.0006* | *0.0008* |
| General Hindu & OBC ratio | 1.9111 ** | 3.0994 *** | 0.9765 | 0.5682 |
| | *0.8192* | *1.0933* | *0.6899* | *0.7099* |
| Distance to Sub-station | -0.0436 ** | -0.0604 ** | -0.0630 *** | -0.0792 *** |
| | *0.0217* | *0.0282* | *0.0239* | *0.0250* |
| Constant | -0.1531 | -1.4164 * | 0.4693 | 0.1323 |
| | *0.5831* | *0.8269* | *0.5415* | *0.5591* |
| No. of observations | 80 | 80 | 80 | 80 |
| Log likelihood | -37.02 | -23.28 | -41.46 | -37.52 |
| Pseudo $R^2$ | 0.293 | 0.373 | 0.249 | 0.245 |

Notes: *, **, and *** indicate the 10%, 5%, and 1% significance; standard errors are in italic. Estimated parameters on district dummies are not shown here.

## 5. Concluding Remarks

This study, based on our surveys in rural Bihar, India, reveals that the status of electrification is not static but rather dynamic. Several once-electrified villages have experienced de-electrification. Due to the insufficient load capacity of government-provided transformers, many villages became de-electrified after their initial electrification. Some villages recovered electricity after making various efforts, but not all villages were able to do so. One problem is that de-electrified villages that are not re-electrified may nonetheless be recorded as electrified villages. According to government statistics, the percentage of electrified villages was around 90% in Bihar, but this does not match the figures from our survey, which were around 53.8% in 2008-09 and 68.8% in 2011-12. We also did not find such a high ratio of village electrification during our field visits. It is not our intention to imply that the RGGVY has not been successful. In fact, it is rather a successful government scheme in terms of implementation, but we should be careful when interpreting figures.

What has become clear from our econometric exercise is that small villages in remote locations tend not to be prioritized in the electrification process. Small and remote villages are usually not financially attractive to electricity providers. Luckily, this problem has been recognized by both the central and Bihar governments, and some actions have already been taken. The central government launched the Decentralized Distributed Generation (DDG) project as part of RGGVY, which is meant to supply electricity from conventional or renewable sources such as biomass to villages where providing an electricity supply through grid connection is either not feasible or not cost effective (Government of India, 2009). The government of Bihar has also documented the difficulty of supplying electricity through the conventional grid and proposed the idea of generating electricity on location through non-conventional systems such as solar or wind power (Government of Bihar, 2008). As for the relationship between electrification and social classes, the cumulative number of ever-electrified villages is higher among villages with higher ratios of socially advanced classes, but some of them became de-electrified and remain un-electrified while the number of newly electrified villages with a higher ratio of lower social classes is increasing, weakening the impact of social classes on electrification.

While rural electrification is continuing under the RGGVY (currently renamed as Deendayal Upadhyaya Gram Jhoti Yojana) and the government celebrates its

accomplishment of connecting electricity to one *lakh* (100,000) villages, challenges nonetheless remain in terms of how small and remote villages become electrified.

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